Project Name: EXPLICIT FINITE ELEMENT ANALYSIS MODELING OF MULTI-LAYER COMPOSITE FABRIC FOR GAS TURBINE ENGINES CONTAINMENT SYSTEMS

Participants: ASU, Honeywell Engine Systems, SRI and NASA-Lewis.

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Abstract: Composite fiber fabric wraps are widely used in the containment systems of gas turbine engines. Such systems are found to be especially cost-effective for mitigating engine debris during fan blade-out event. This is mostly because of their high strength per unit weight property. Moreover they are inexpensive to manufacture compared with the traditional metallic containment systems. To properly utilize this advantage from a design perspective, it is necessary to have a robust finite element modeling methodology.

The major objective of this research project is to develop a material model for dry fabrics (Kevlar and Zylon) that can be used in the context of a finite element analysis of a fan-blade out event. To facilitate this goal, the project is divided into several major tasks with their underlying subtasks. First, a series of experiments have been defined to find the basic load-deflection followed by stress-strain curves for the fabrics. The intent is to use these stress-strain curves in the finite element analysis. Second, the use of these fabrics in engine containment structures is approximated by a 32 in diameter and 6 in wide steel ring. The ring is wrapped with different number of Kevlar and Zylon layers, and the wrapped assembly is subjected to load on the fabric applied through a blunt nose penetrator until failure of the fabric. This Static Ring Test has been carried out on 1, 2, 4, 8, and 24 layers of Kevlar and Zylon fabrics. Third, the developed material model (using results from Task 1) is then used in a FE analysis of the Static Ring Tests and the results (load-tip deflection) are compared to the Static Ring Test results. Fourth, to mimic a fan blade out situation, a 40 in diameter steel ring is used that is wrapped with a different number of fabric layers. The entire assembly is subjected to a "blunt" projectile launched from a gun at varying velocities. Data on the projectile is obtained through the use of high-speed cameras, and the data analysis yields displacement, velocity and energy absorbed. This Ballistic Tests has been carried out on a number of differing number of Kevlar and Zylon layers, and braids/fabrics. Fifth, a FE simulation of the Ballistic Tests is underway to compute the analytical displacements, velocities and energy absorption values so as compare against the experimentally obtained values. Last, the experience gained from the FE analysis of the Static and Ballistic Tests will be used in the development of methodology and best practices for the use of FE modeling techniques in predicting fan blade out simulations. Actual fan blade out condition and simulation will be carried out through the use of simplified "generic engine" models supplied by Honeywell Engine Systems, Inc.

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